How to Study Better Quicker

based on Cognitive Science

Taffeta Elliott, PhD
Psychology

NEW MEXICO TECH
SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

2025 S-STEM Scholars Meeting

Oct. 3, 2025
San Diego

Listen

Study

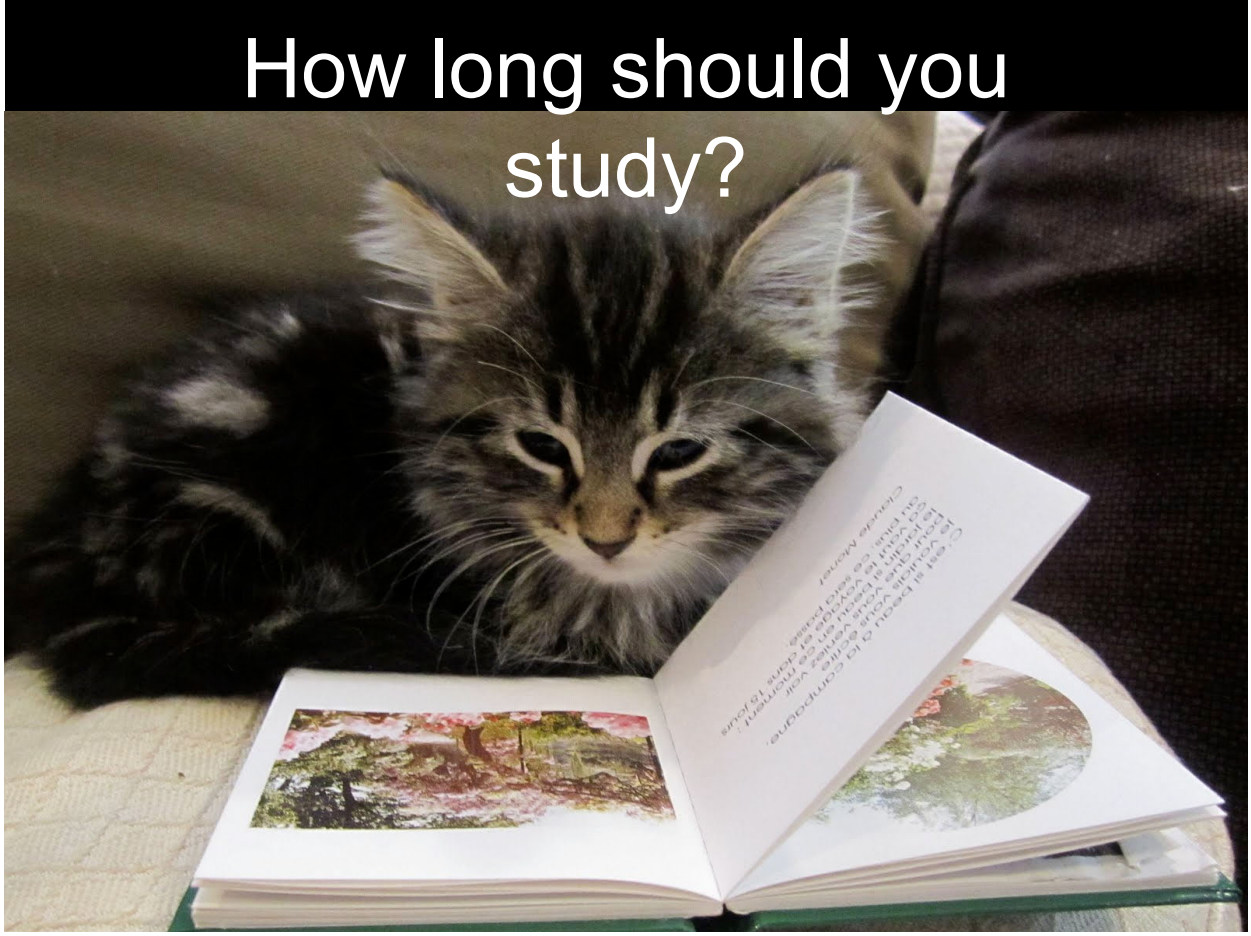
6 study strategies outside class

Take exam

Reflect on it to improve study

Beyond

How long should you study?



College expects you to work more outside of class

Workload Estimator 2.0

https://cat.wfu.edu/resources/tools/estimator2/

WAKE FOREST UNIVERSITY

Center for the Advancement of Teaching

COURSE INFO

Class Duration (Weeks): 15

READING ASSIGNMENTS

Pages Per Week: 40

Page Density: 600 Words

Difficulty: Some New Concepts

Purpose: Understand

Estimated Reading Rate: 18 pages per hour

manually adjust

WRITING ASSIGNMENTS

Pages Per Semester: 3

Page Density: 250 Words

Genre: Argument

Drafting: Minimal Drafting

Estimated Writing Rate: 2 hours per page

manually adjust

VIDEOS / PODCASTS

Hours Per Week: 0

DISCUSSION POSTS

Posts per Week: 0.3

Format: Text

Avg. Length (Words): 250

Estimated Hours: 0.3 hours / week

OTHER ASSIGNMENTS

 # Per Semester: 10

Hours Per Assignment: 1 — 50 (0 5 10 15 20 25 30 35 40 45 50)

Independent

CLASS MEETINGS

Live Meetings Per Week:

WORKLOAD ESTIMATES

Total: 7.92 hrs/wk

Independent: 4.62 hrs/wk

Contact: 3.3 hrs/wk

Example: 3 credit hour Intro Psych

WORKLOAD ESTIMATES

Total: 7.92 hrs/wk

Independent: 4.62 hrs/wk

Contact: 3.3 hrs/wk

Multiply class hours by x1.5 to estimate time spent on your own

Example:
3 credit General Chemistry I

15 minutes per math problem

Computer programming assignments could often be harder to predict...

Make time to

READ ACTIVELY

Bring questions to class

Listen

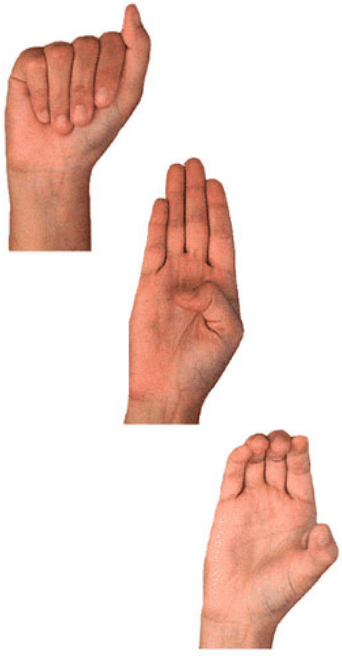
Study

Take exam

Beyond

6 study strategies on your own

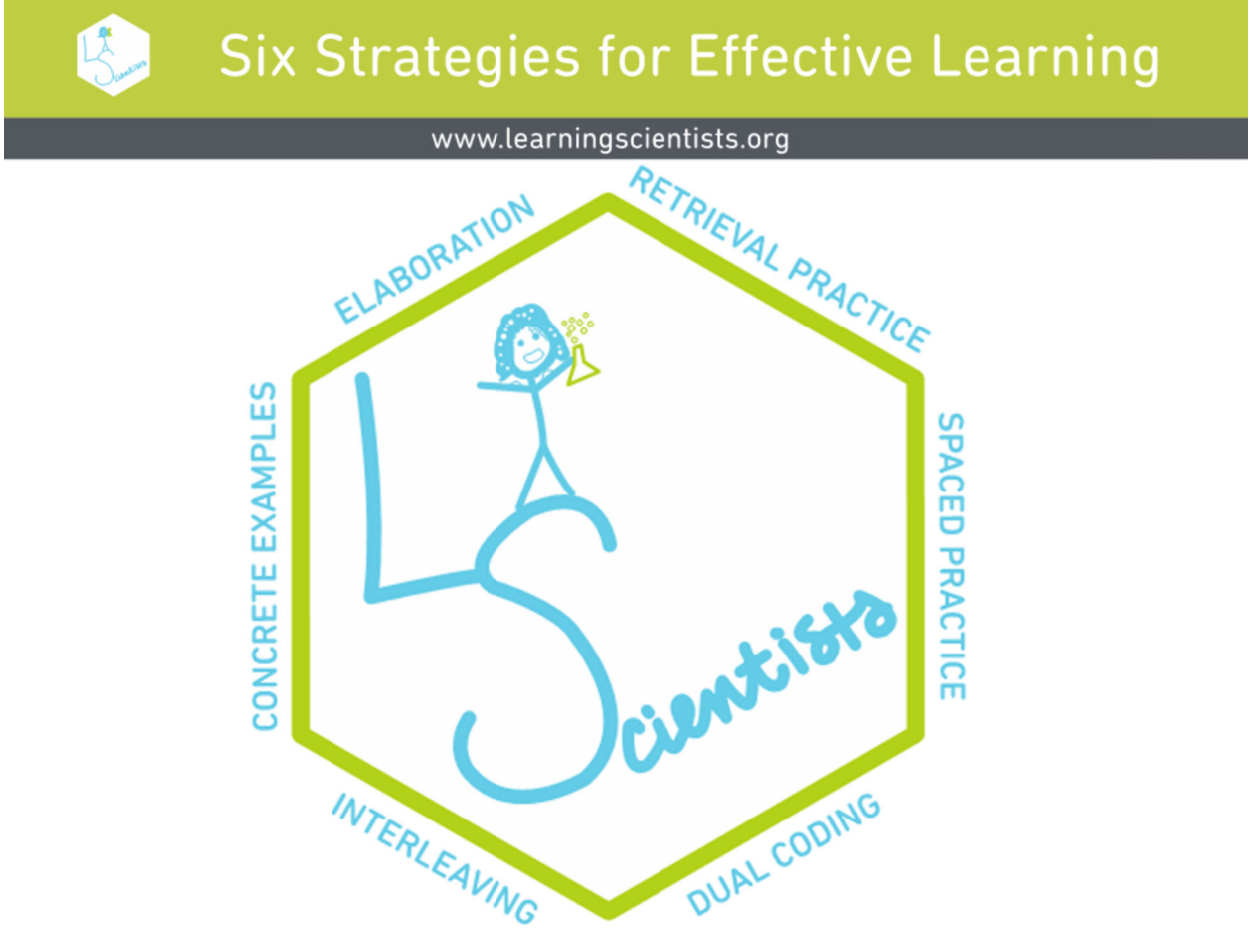
Which study strategy do ***you*** use most often?

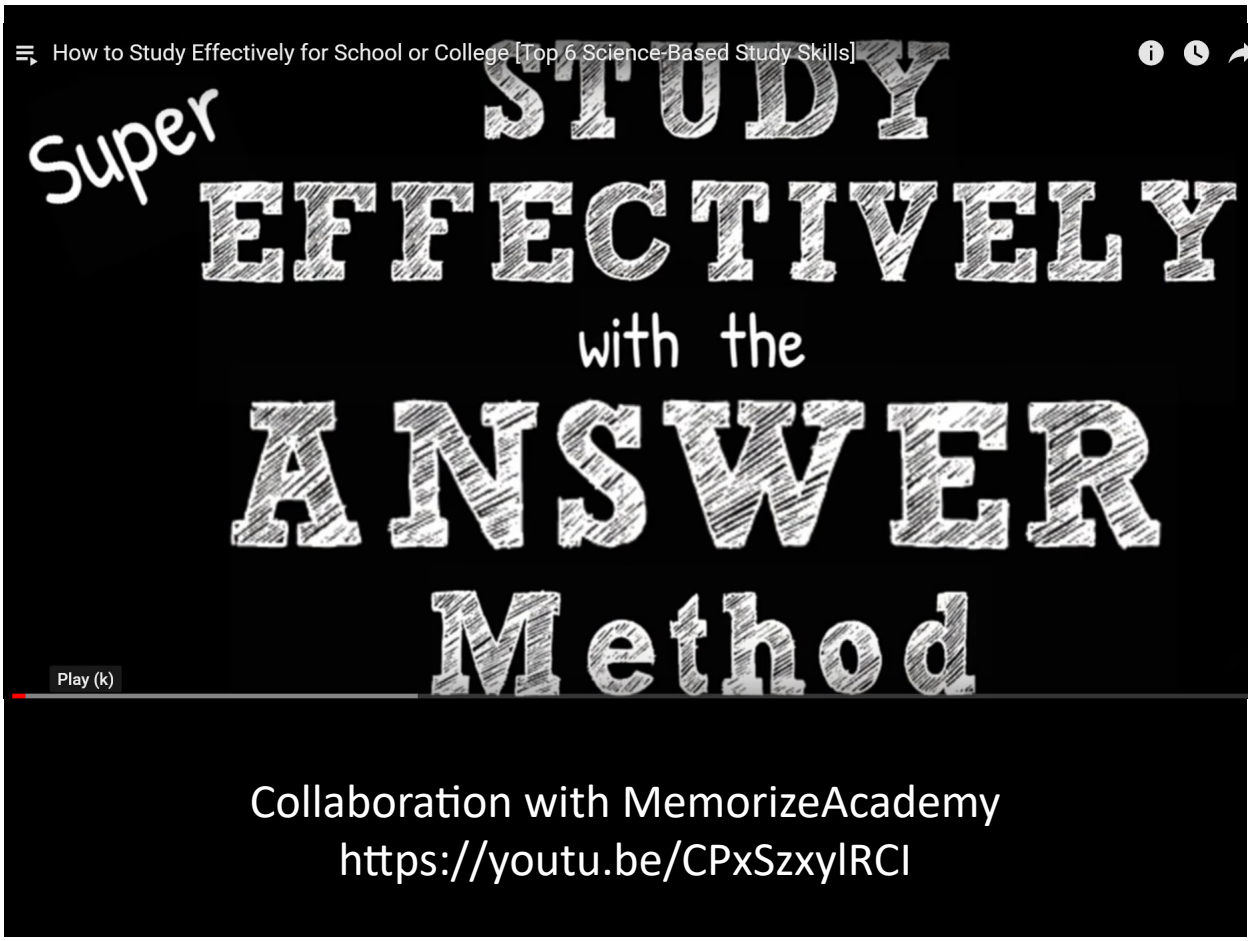


A. Highlighting

B. Re-reading the textbook/notes

C. Quizzing





Collaboration with MemorizeAcademy
https://youtu.be/CPxSzxylRCI

3 purposes of the 6 strategies

A. Planning learning
   - 1 Spaced Practice
   - 2 Interleaving

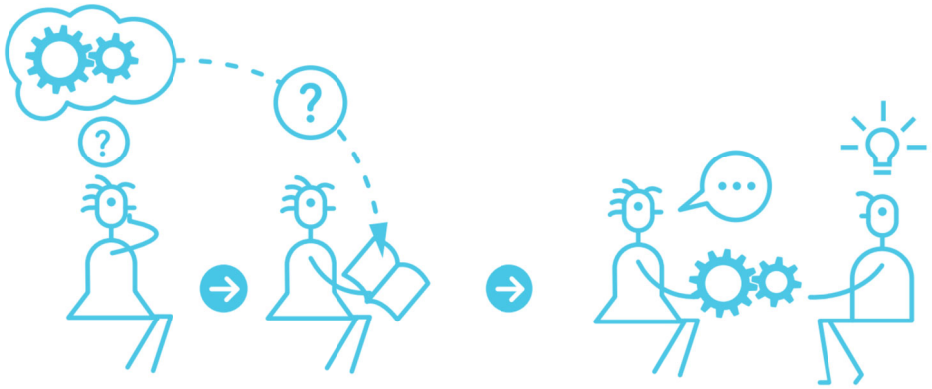
B. Developing understanding
   - 3 **Concrete Examples**
   - 4 **Dual Coding**
   - 5 **Elaboration**

C. Reinforcing learning
   - 6 Retrieval Practice

Elaboration

HOW TO DO IT

Ask yourself questions while you are studying about how things work and why, and then find the answers in your class materials and discuss them with your classmates.

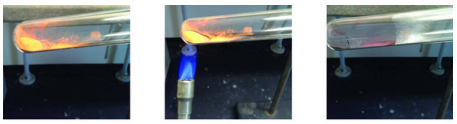


Classifying Matter

Matter can be classified into several categories. Two broad categories are mixtures and pure substances. A pure substance has a constant composition. All specimens of a pure substance have exactly the same makeup and properties. Any sample of sucrose consists of 42.1% carbon, 6.5% hydrogen, and 51.4% oxygen by mass. Any sample of sucrose also has the same physical properties, such as melting point, color, and sweetness, regardless of the source from which it is isolated.

Pure substances may be divided into two classes: elements and compounds. Pure substances that cannot be broken down into simpler substances by chemical changes are called elements. **Iron, silver, gold, aluminum, sulfur, oxygen**, and **copper** are familiar examples of the more than 100 known elements, of which about 90 occur naturally on the earth, and two dozen or so have been created in laboratories.

Classifying Matter (cont'd)



Pure substances that are comprised of two or more elements are called compounds. Compounds may be broken down by chemical changes to yield either elements or other compounds, or both. **Mercury(II) oxide**, an orange, crystalline solid, can be broken down by heat into the elements mercury and oxygen (Fig. 1.9). When heated in the absence of air, the compound **sucrose** is broken down into the element carbon and the compound water. (The initial stage of this process, when the sugar is turning brown, is known as caramelization—this is what imparts the characteristic sweet and nutty flavor to caramel apples, caramelized onions, and caramel). **Silver(I) chloride** is a white solid that can be broken down into its elements, silver and chlorine, by absorption of light. This property is the basis for the use of this compound in photographic films and photochromic eyeglasses (those with lenses that darken when exposed to light).

…A **mixture** is composed of two or more types of matter that can be present in varying amounts and can be separated by physical changes, such as evaporation.

Study Strategy 3. **Elaboration**

a. What are your **questions** about how things work, and why, in Figure 1.9 (or some other part of the passage)?

b. Find answers to your questions in the book or your class notes, etc. In this case, the following "Learning Link" box of the textbook gives you links to YouTube videos that would answer my first question: "Many compounds break down when heated [or illuminated]. This site shows the breakdown of mercury oxide, HgO. Another example is the photochemical decomposition of silver chloride (AgCl), the basis of early photography."

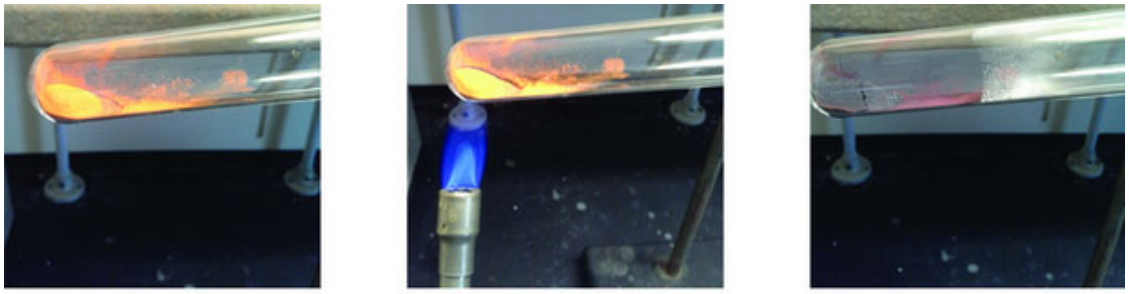


Fig. 1.9 (a) The compound mercury(II) oxide,

(b) when heated,

(c) decomposes into silvery droplets of liquid mercury and invisible oxygen gas.

(credit: modification of work by Paul Flowers)

c. Make **connections** to show how ideas work together.

One way to make connections in this case is to compare and contrast concepts. For example, compare and contrast chemical *production* and *decomposition*, or *composition* in sentence 3 of the 1st paragraph you read.

Similarities: Both *production* and *decomposition* are transitions between some constituent pure elements, and some compounds made of those constituents. Either kind of reaction results in some yielded substance that wasn't there before, and sometimes one element could be separated from a compound at the same time as two other elements newly combine (like burning hydrogen, $2H_2 + O_2 \rightarrow 2H_2O$). Both synthesis and decomposition can involve heat (in a reaction that has to absorb it, or produces it).

Contrasts: *Decomposition* disintegrates the substance into simpler parts, whereas *synthesis* builds up a combination that's inherently more complex in its constitution than its parts were alone.

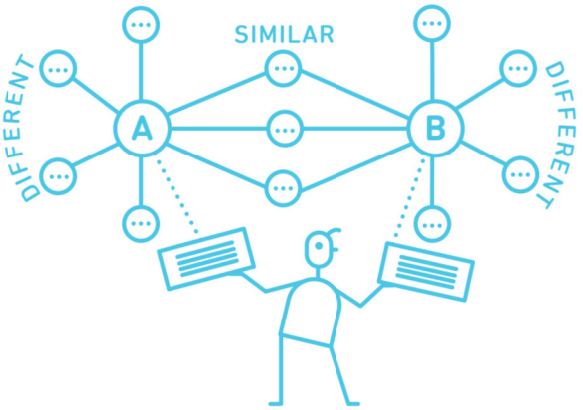
Contrast of both terms with *composition*: Composition is a static makeup (in terms of parts or elements), rather than a change in constitution.

- Now, try to make your own connection between a couple of ideas in the reading.

Elaboration

HOW TO DO IT

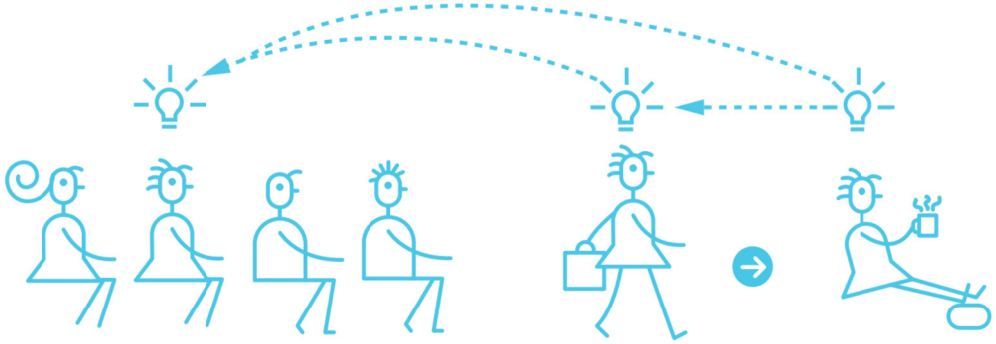
As you elaborate, make connections between different ideas to explain how they work together. Take two ideas and think of ways they are similar and different.



Elaboration

HOW TO DO IT

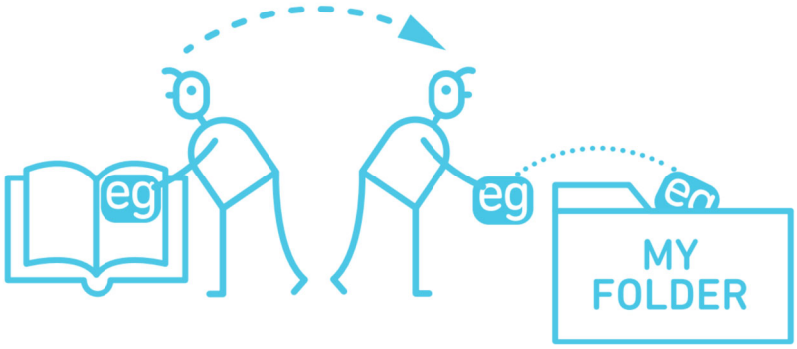
Describe how the ideas you are studying apply to your own experiences or memories. As you go through your day, make connections to the ideas you are learning in class.



Concrete Examples

HOW TO DO IT

Collect examples your teacher has used, and look in your class materials for as many examples as you can find.



Study Strategy 1. **Concrete Examples** of an abstract concept (like chemical *compounds* or *decomposition*)

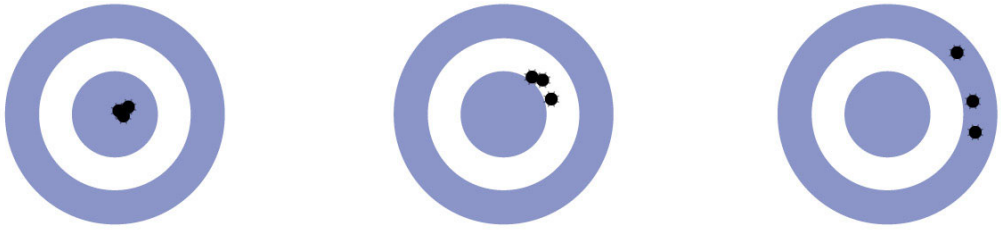
- Write 3 of your own concrete examples of *compounds* that can be broken down into *elements*:

<u>Note:</u> These should be your own examples, which means distinct from the three examples in the reading passage.

Accuracy and Precision

Scientists typically make repeated measurements of a quantity to ensure the quality of their findings and to evaluate both the precision and the accuracy of their results. Measurements are said to be precise if they yield very similar results when r epeated in the same manner. A measurement is considered accurate if it yields a result that is very close to the true or accepted value. Precise values agree with each other; accurate values agree with a true value. These characterizations can be extended to other contexts, such as the results of an archery competition (Figure 1.27).

Figure 1.27 (a) These arrows are close to both the bull's eye and one another, so they are both accurate and precise. (b) These arrows are close to one another but not on target, so they are precise but not accurate. (c) These arrows are neither on target nor close to one another, so they are neither accurate nor precise.

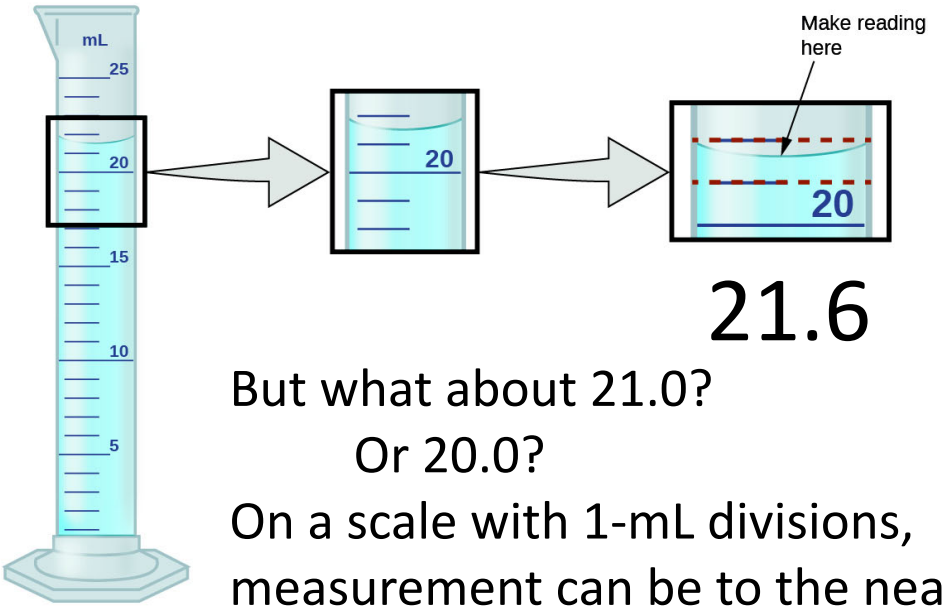


Accurate and precise (a)

Precise, not accurate (b)

Not accurate, not precise (c)

Can zeros at the end of a measurement ever be significant?



21.6

But what about 21.0?

Or 20.0?

On a scale with 1-mL divisions, measurement can be to the nearest 0.1 mL.

Concrete Examples

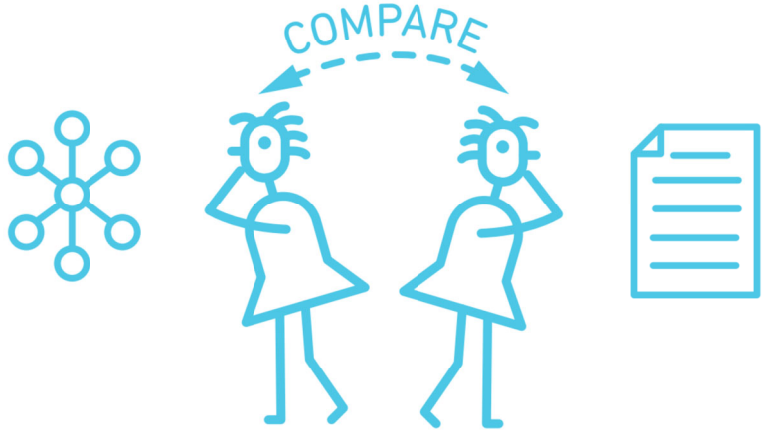
HOW TO DO IT

Make the link between the idea you are studying and each example, so that you understand how the example applies to the idea.

Dual Coding

HOW TO DO IT

Look at your class materials and find visuals. Look over the visuals and compare to the words.



Dual Coding

HOW TO DO IT

Look at visuals, and explain in your own words what they mean.

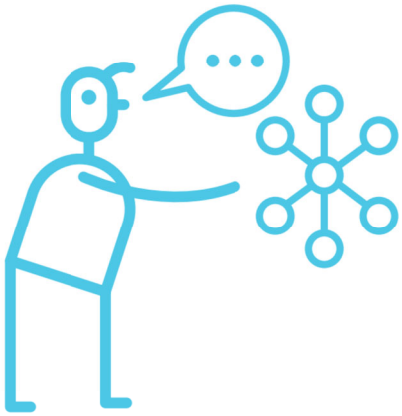
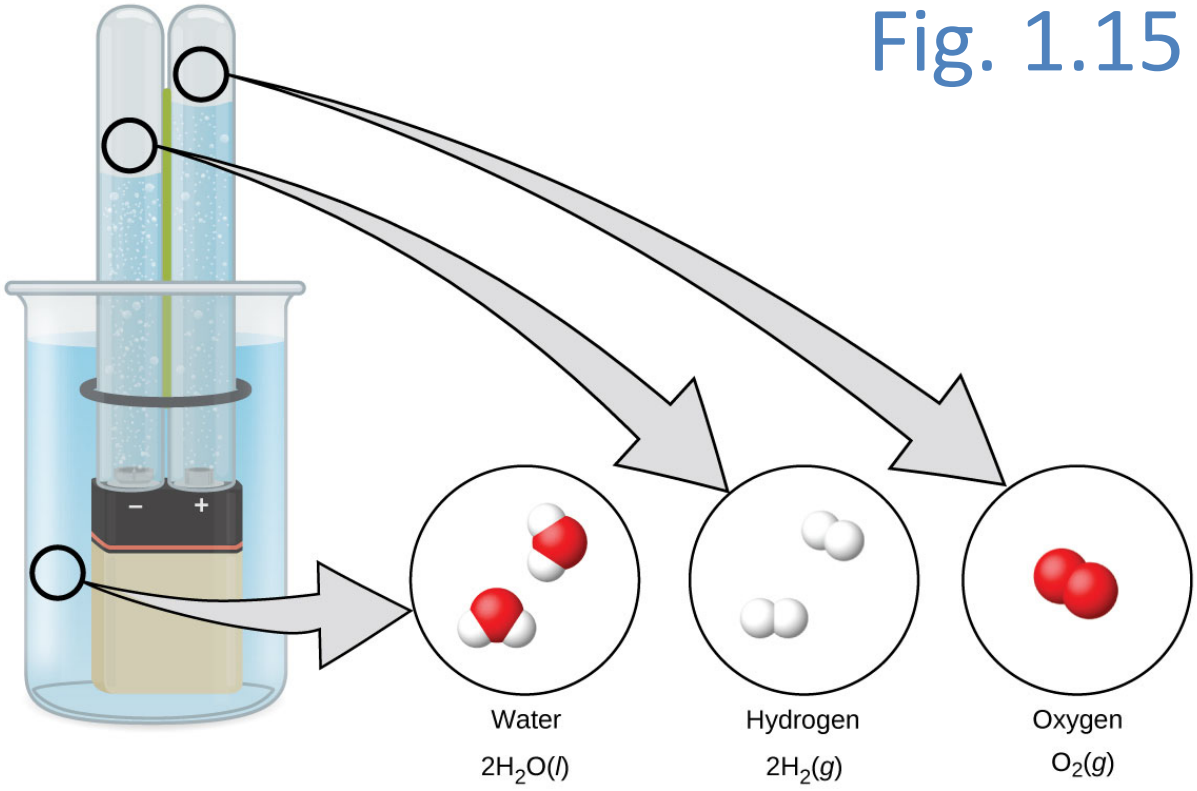


Fig. 1.15

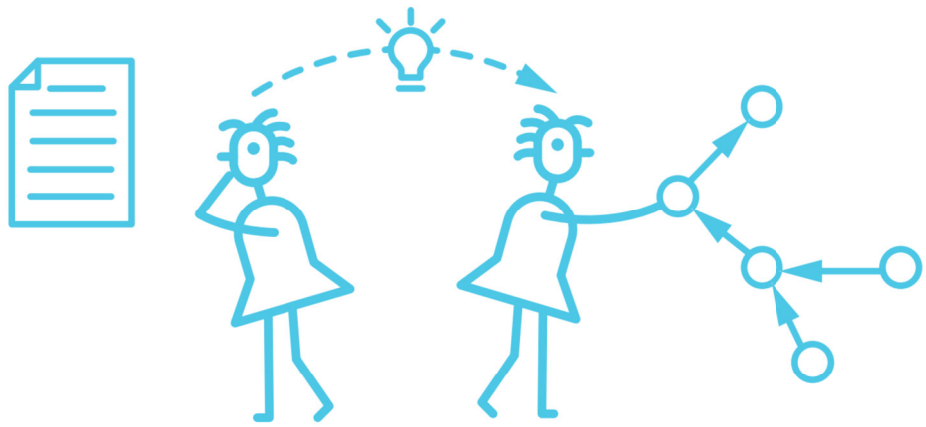


$$2H_2O(\square) \longrightarrow 2H_2(\square) + O_2(\square)$$

Dual Coding

HOW TO DO IT

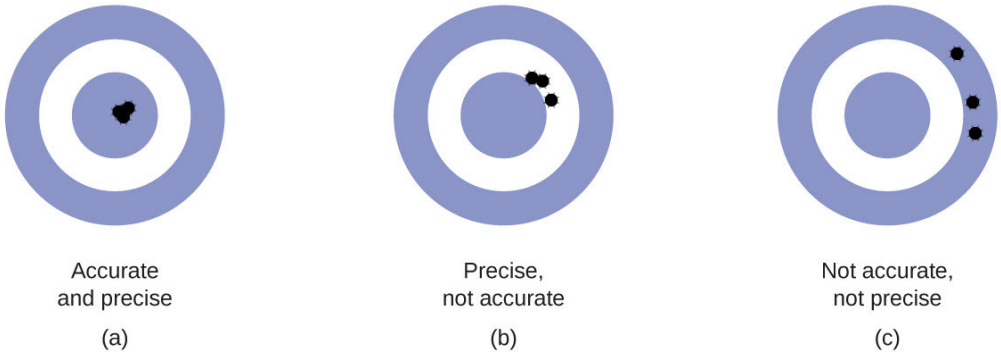
Take information that you are trying to learn, and draw visuals to go along with it.



Accuracy and Precision

Scientists typically make repeated measurements of a quantity to ensure the quality of their findings and to evaluate both the precision and the accuracy of their results. Measurements are said to be precise if they yield very similar results when r epeated in the same manner. A measurement is considered accurate if it yields a result that is very close to the true or accepted value. Precise values agree with each other; accurate values agree with a true value. These characterizations can be extended to other contexts, such as the results of an archery competition (Figure 1.27).

Figure 1.27 (a) These arrows are close to both the bull's eye and one another, so they are both accurate and precise. (b) These arrows are close to one another but not on target, so they are precise but not accurate. (c) These arrows are neither on target nor close to one another, so they are neither accurate nor precise.

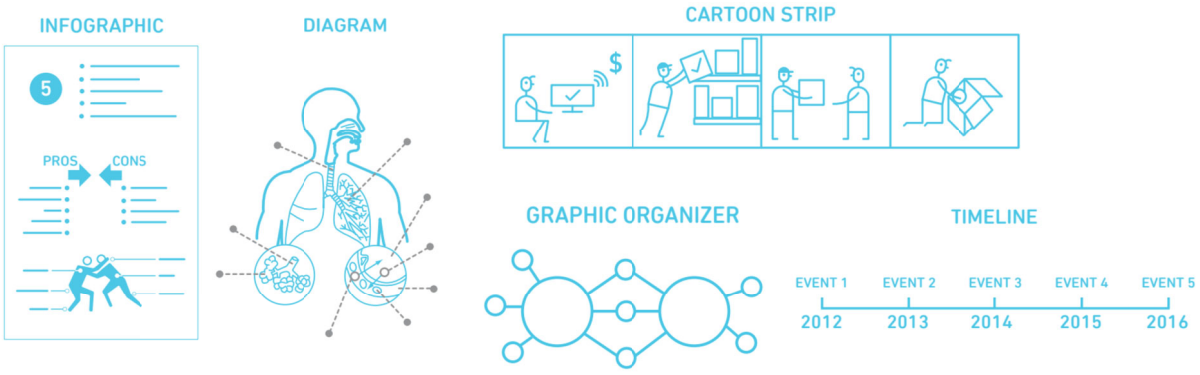


Here's another chance for a **Concrete Example** that you can draw [**Dual Coding!**] from the text: What would a measurement sample look like, against a bull's-eye truth represented as a target, if the measurements were accurate but ***not*** precise? Take for example sewage sampling for covid rates in a community. How would that category of measurement look, as an addition "(d)" to Fig. 1.27?

Dual Coding

HOLD ON!

Try to come up with different ways to represent the information visually, for example an infographic, a timeline, a cartoon strip, or a diagram of parts that work together.



3 purposes of the 6 strategies

A. Planning learning
   - 1 Spaced Practice
   - 2 Interleaving

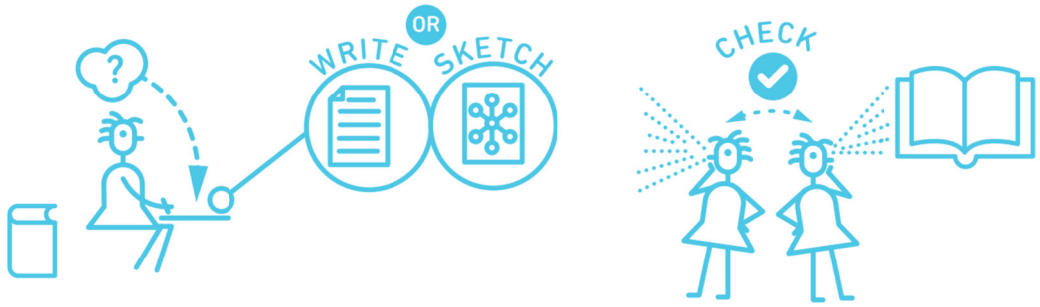
B. Developing understanding
   - 3 Concrete Examples
   - 4 Dual Coding
   - 5 Elaboration

C. Reinforcing learning
   - 6 **Retrieval Practice**

Retrieval Practice

HOW TO DO IT

Put away your class materials, and write or sketch everything you know. Be as thorough as possible. Then, check your class materials for accuracy and important points you missed.



Study strategy 4. **Retrieval practice**

- Write everything you know about the LO

"Classify matter as an element, compound, **homogeneous mixture, or heterogeneous mixture** with regard to its **physical state and composition**"

Retrieval Exercise 17.

- Classify each of the following as *E* an element, *C* a compound, or *M* a mixture:

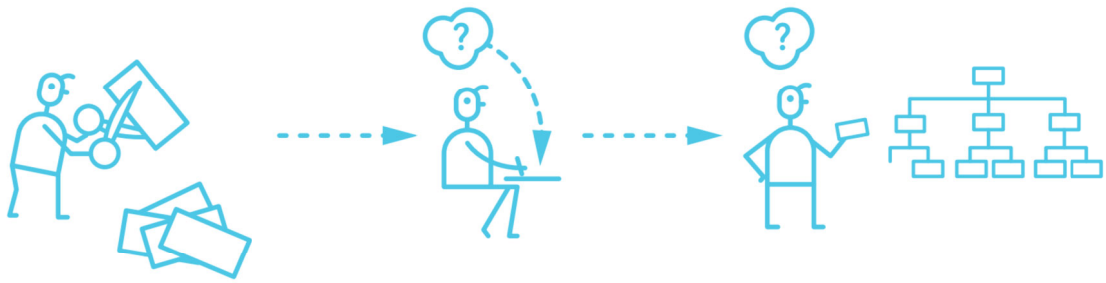
(a) iron
(b) oxygen
(c) mercury oxide
(d) pancake syrup
(e) carbon dioxide
(f) a substance composed of molecules each of which contains one hydrogen atom and one chlorine atom
(g) baking soda
(h) baking powder

(a) element;
(b) element;
(c) compound;
(d) mixture;
(e) compound;
(f) compound;
(g) compound;
(h) mixture

Retrieval Practice

HOW TO DO IT

You can also make flashcards. Just make sure you practice recalling the information on them, and go beyond definitions by thinking of links between ideas.



3 purposes of the 6 strategies

A. Planning learning
   - 1 **Spaced Practice**
   - 2 **Interleaving**

B. Developing understanding
   - 3 Elaboration
   - 4 Dual Coding
   - 5 Concrete Examples

C. Reinforcing learning
   - 6 Retrieval Practice

Spaced Practice

HOW TO DO IT

After you review information from the most recent class, make sure to go back and study important older information to keep it fresh.

Spaced Practice example

In-class Study Homework

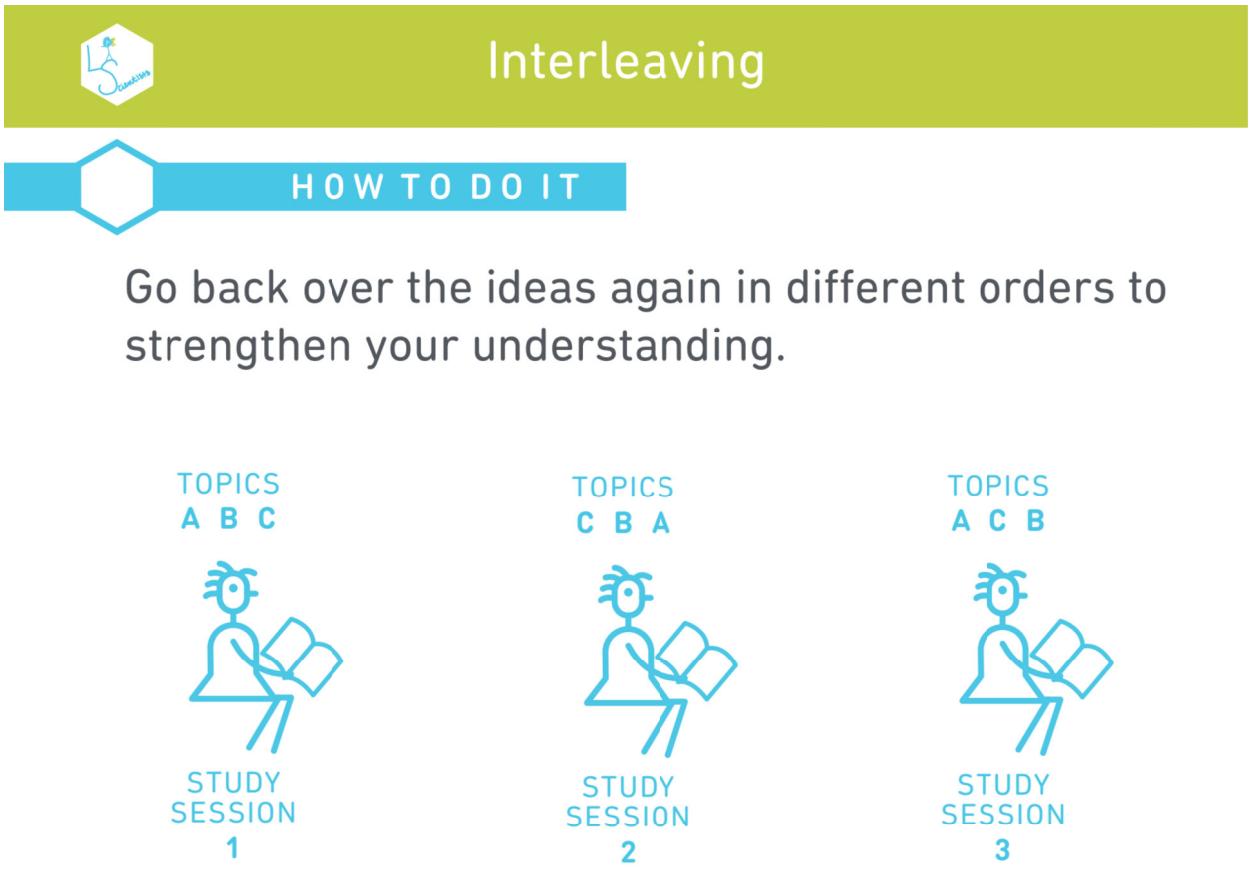
Interleaving

HOW TO DO IT

Switch between ideas during a study session. Don't study one idea for too long.

Interleaving example

- Physical and chemical properties
- Significant figures
- Macroscopic, microscopic and symbolic domains
- Scientific method
- Phases and classification of matter
- Accuracy and precision
- Hypotheses vs. theory
- Measurement uncertainty



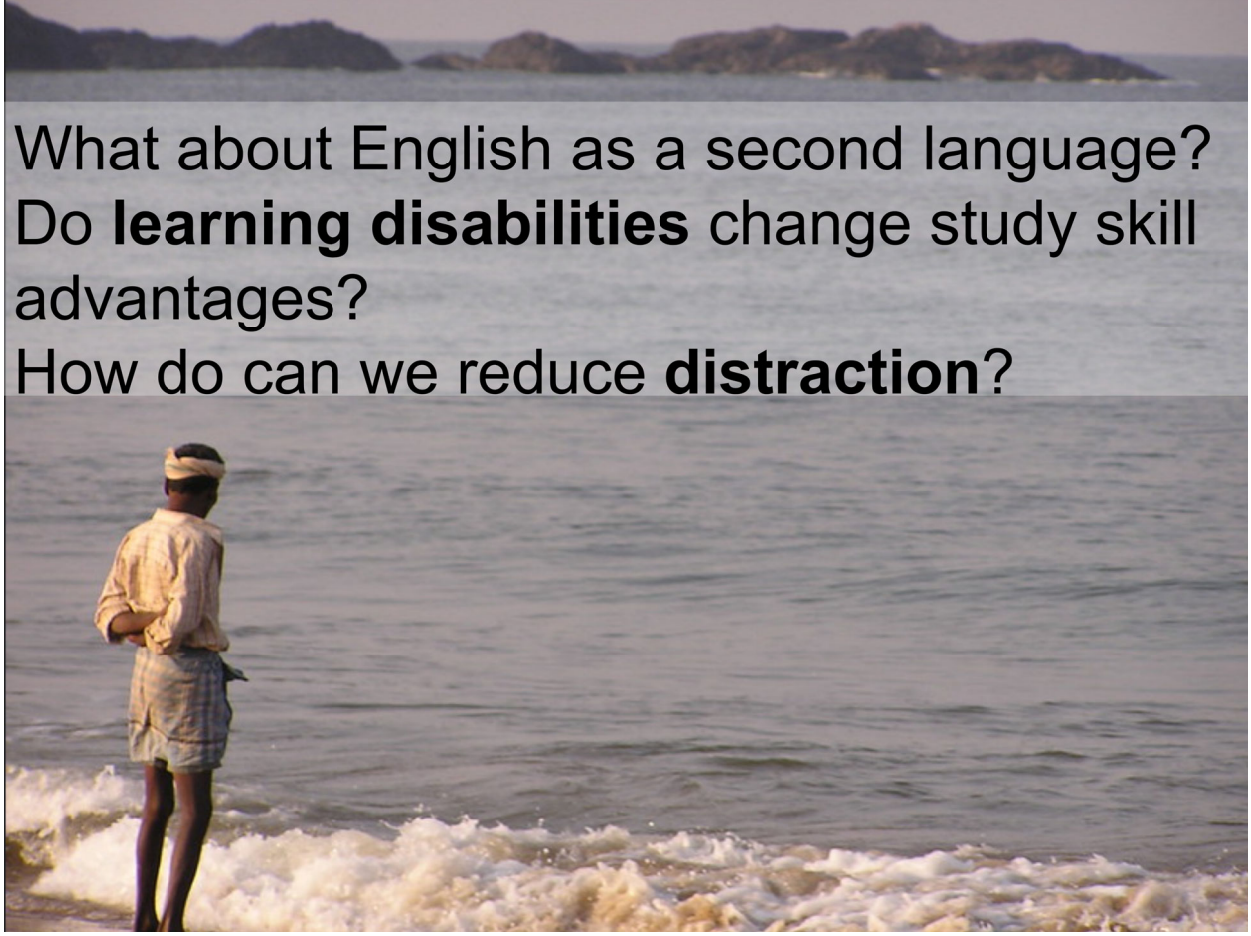
Interleaving

HOW TO DO IT

Make links between different ideas as you switch between them.

Form **STUDY GROUPS**

- **Concrete examples** Share examples with friends and explain them to each other
- **Retrieval practice** Try making your own questions and trading with a friend who wrote their own
- **Elaboration** When you explain to a friend, check that you're not overextending ideas or missing something. Check each other against materials, or ask tutor/teacher later.
- **Dual coding** Does your classmate have a different kind of representation, or way of organizing and connecting ideas?



English as a Second Language?

- Start with the visuals: figures
- Seek help when instructions are unclear
  - Focus on the important learning goals
- Immersive practice
  - Even when you're not in the mood
  - Generate language art, songs
- Dictionary: look up words you don't know

Prioritization

- Eisenhower matrix

	Urgent	Not Urgent
Important	**Urgent & Important** - Paper due tomorrow - Apply for internship by deadline	**Not Urgent, but Important** - Flu shot - Later exams & projects
Not Important	**Urgent but Not Important** - Laundry - Store sale	**Neither urgent nor important** - Check social media - Video feed

Procrastination

- Break down the goal into manageable tasks
- Calendars and reminders
- Own it (why *you* adopted this goal)
- Confront the negative emotions
  - Your larger purpose is a positive. Forgive yourself.
  - Visualize achieving the results (& reward yourself)
  - Surround yourself with positive people working towards their own goals
  - Tell others your plan

Post-Exam Reflection

If exams are not handed back, use a practice exam

1. Note the questions you got wrong or lost some points on and consider why that's the case. Here is a (non-exhaustive) list of some potential reasons:
    a) Misunderstood the question
    b) Didn't know the material/unfamiliar with the concept
    c) Difficulty applying a concept to a new context
    d) Overthought the question/thought it was a trick question
    e) Didn't know where to start
    f) Careless mistake
    g) Running out of time and had to rush

    After writing down that information, you can also note the question type, as well as the concept that was being assessed. This will be helpful in the subsequent step.

Question #	Why I got it wrong?	Question Type	Concept

If you…
then **during *class*** you should:

…had more careless mistakes

- SLOW DOWN!
- Check your work with a partner
- Explain your thinking to classmates
- Keep track of types of mistakes, to see if you repeat some kinds

…had more "Didn't know how to solve"

- Ask questions about what didn't seem right in your homework
- Start working on problems with the class (follow along)
- Use every opportunity to check your work with peers or the teacher

If you…
then **during *exams*** you should:

…had more careless mistakes

- SLOW DOWN.
- REALLY **double-check** your work (since you know you tend to make careless errors)
- Use **inverse operations** when you have extra time

…had more "Didn't know how to solve"

- **First** do problems you are most confident about
- Then take your time with the rest, and start by using whatever you do know that's related
- Ask questions as soon as possible after the exam, while a struggle is fresh

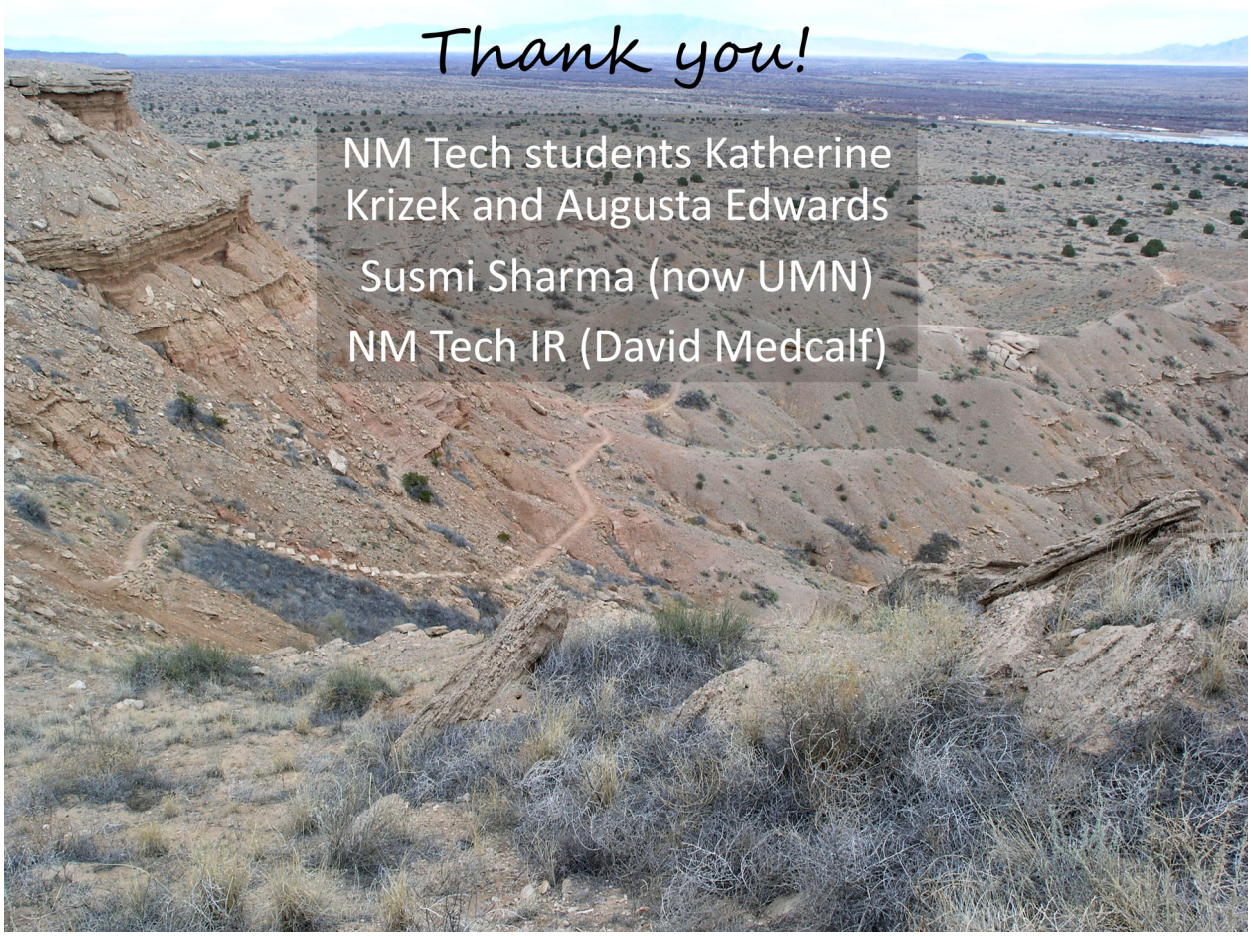
Counseling offers talks on Test Anxiety

Do These Things:

- Get your sleep the night before the test
- Eat a light snack before your exam (food = brain power)
- Some light stretching to work on your physical stress
- Drink water
- Set an alarm
- Have a celebratory dance party when you are done

Do NOT do these things:

- Stay up all night cramming.
- Take your exam on just coffee (if you are nervous or anxious only having coffee can make it worse)
- Sit in the same position for five (5) hours straight
- Forget your calculator
- Accidentally set your alarm for PM and miss your test
- Invite other people over for the dance party (social distancing is still in effect)



The Science of Learning

www.learningscientists.org

CREATOR

Yana Weinstein — University of Massachusetts Lowell

CREATOR

Megan Smith — Rhode Island College

ILLUSTRATOR

Oliver Caviglioli — www.teachinghow2s.com/cogsci

FUNDED BY

APS Fund for Teaching & Public Understanding of Psychological Science